Late Jurassic invertebrate fossils from the Little Hatchet Mountains, southwestern New Mexico

by *Spencer G. Lucas*, New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, NM 87104;
Kate E. Zeigler, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131;
Timothy F. Lawton, Department of Geological Sciences, New Mexico State University, Las Cruces, NM 88003; and
Harry F. Filkorn, Department of Geology, Kent State University, Kent, OH 44242

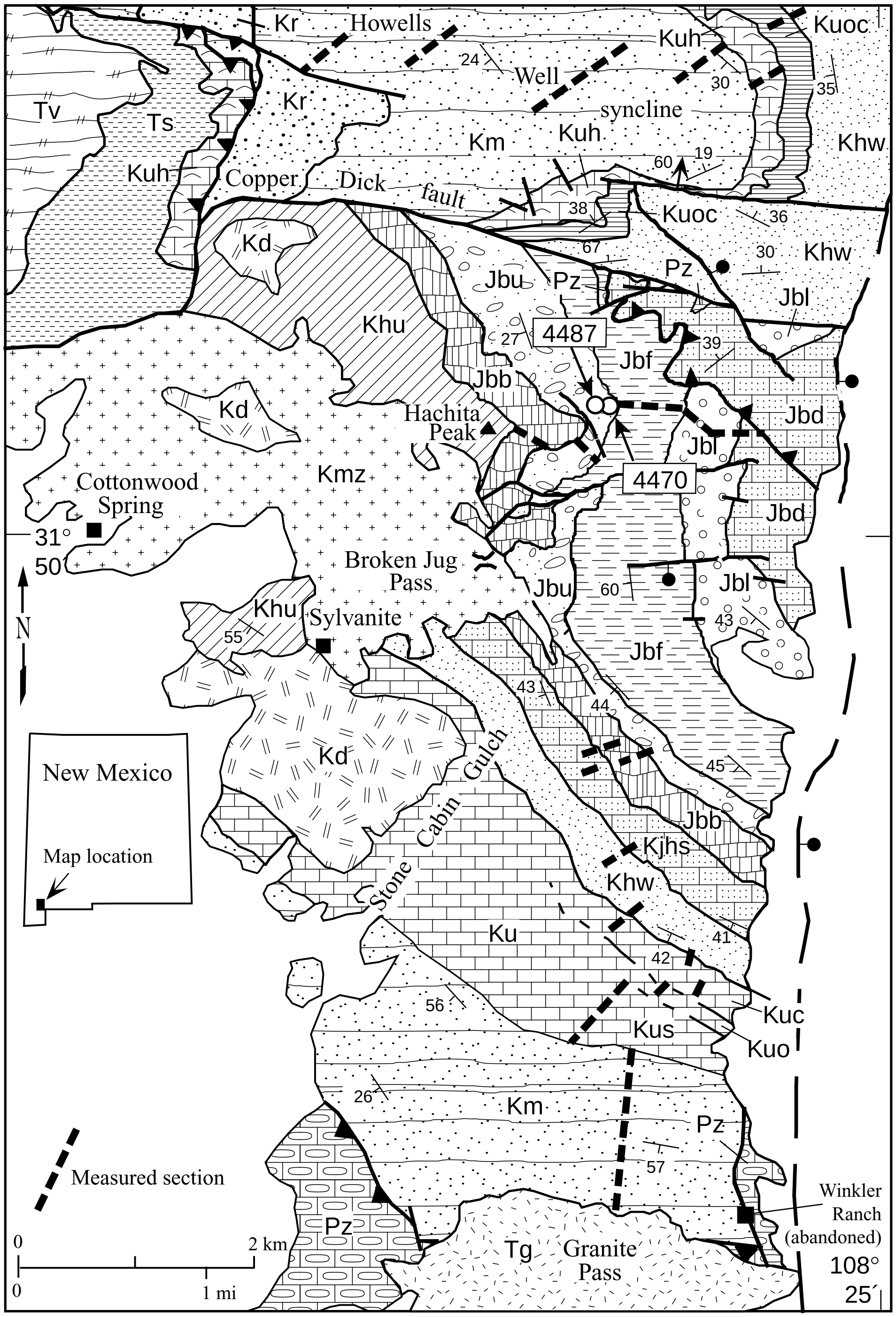


FIGURE 1—Geologic map of part of the southern Little Hatchet Mountains showing the fossil localities (**4470**, **4487**) in the Broken Jug Formation. **Pz**, undifferentiated Paleozoic strata. Bisbee Group: Broken Jug Formation—**Jbd**, dolostone member; **Jbl**, lower conglomerate member; **Jbf**, fine-grained member; **Jbu**, upper conglomerate member; **Jbb**, basalt member; Hell-to-Finish Formation—**Khu**, undifferentiated Hell-to-Finish Formation; **KJhs**, Stone Cabin Gulch Member; **Khw**, Winkler Ranch Member; U-Bar Formation—**Ku**, undifferentiated U-Bar Formation; **Kuc**, Carbonate Hill Member; **Kuo**, Old Hachita Member; **Kuoc**, Carbonate Hill and Old Hachita Members, undifferentiated; **Kuh**, Howells Ridge Member; **Km**, Mojado Formation; **Kr**, Ringbone Formation; **Kmz** and **Kd**, cogenetic monzonite and diorite plutons; **Ts**, Skunk Ranch Formation; **Tg**, Tertiary granite; **Tv**, Tertiary volcanic rocks. Modified from Lucas and Lawton (2000).

Abstract

Invertebrate fossils from the upper conglomerate member of the Broken Jug Formation, the basal unit of the Bisbee Group in the Little Hatchet Mountains of southwestern New Mexico, are bivalves (cf. *Gryphaea mexicana* Felix), gastropods (Nerineidae), and a coral (*Thamnasteria* sp. cf. *T. imlayi* Wells). These fossils indicate a Late Jurassic age and support correlation of the Broken Jug Formation with the Kimmeridgian–Tithonian La Casita Formation of northern Mexico. The presence of Upper Jurassic marine strata in southwestern New Mexico confirms identification of a Late Jurassic Mogollon paleo-highland in west-central New Mexico and east-central Arizona that separated the Bisbee rift basin to the south from the coeval fluvial depositional basin of the Morrison Formation to the north.

Introduction

Mesozoic marine stata underlie sedimentary rocks of known Early Cretaceous age in the Little Hatchet Mountains of southwestern New Mexico. A possible Jurassic age for these rocks, which are presently known only from exposures east and southeast of Hachita Peak (Fig. 1), was first suggested by Zeller (1970). Harrigan (1995) and Lawton and Harrigan (1998) identified these strata as the Broken Jug Formation and assigned them a Jurassic age based on their stratigraphic position and similarity to Jurassic strata in southeastern Arizona and Chihuahua, Mexico. Lucas and Lawton (2000) followed these conclusions and noted the presence of Jurassic invertebrate fossils in the upper part of the Broken Jug Formation. Here, we describe these fossils, determine their biostratigraphic significance, and briefly discuss the paleogeographic implications of the presence of Upper Jurassic marine strata in southwestern New Mexico.

Stratigraphy

The fossils described here come from two localities on the eastern slope of Hachita Peak in the SE¼ NE¼ sec. 26 T28S R16W, Hidalgo County (Fig. 1). P. Harrigan discovered New Mexico Museum of Natural History (NMMNH) locality 4470, which yielded the gastropods and coral described here (also see Lawton and Harrigan, 1998, fig. 2). S. G. Lucas discovered NMMNH locality 4487, which yielded the bivalves described here. Locality 4487 is just west of locality 4470 and approximately 40 m (131 ft) higher stratigraphically. Both localities are near the base of the upper conglomerate member of the Broken Jug Formation (Fig. 2; Lucas and Lawton, 2000, fig. 3).

Bivalves

At NMMNH locality 4487, a coquina bed yields many bivalves catalogued as NMMNH P-32956–32961. These bivalves (Fig. 3A–H) are characterized by a small left valve that has a thick shell wall, is triangular in outline, and is clearly much larger than the right valve. The left valve is moderately convex to deeply excavated and is strongly arched dorsally. The beak is bluntly hooked, and the presence of a sulcus from the beak downward to produce a wing-like flare of the posteroventral margin is difficult to determine on most specimens due to poor preservation; however, it is visible on some specimens (e.g., Fig. 3D–E, H). The incurved beak is prominent but incomplete on all specimens due to abrasion. Those specimens with preserved external shell morphology show acute, imbricate, concentric growth lines and undulations (Fig. 3D). The shell is higher than long; left valve heights range from 30 to 35 mm (1.2–1.4 inches), and left valve lengths are much more variable, ranging from 10 to 30 mm (0.4–1.4 inches).

These specimens closely resemble specimens of *Gryphaea mexicana* Felix illustrated by Felix (1891, pl. 27, figs. 30–30a), Cragin (1905, pl. 3, figs. 1–6), and Imlay (1940, pl. 54, figs. 1–7). As Imlay (1940) stressed, left valves of *G. mexicana* are highly variable, and the specimens from the Little Hatchet Mountains fall within this range of variation. Therefore, but in view of the poor preservation of the specimens from the Little Hatchet Mountains, we tentatively assign them to that taxon as cf. *Gryphaea mexicana*. *Gryphaea mexicana* is known from Upper Jurassic strata in Oaxaca and Durango, Mexico, and the Malone Mountains of west Texas (Felix, 1891; Cragin, 1905; Imlay, 1940).

Gastropods

NMMNH P-31554, collected by P. Harrigan at locality 4470, in a grainstone bed 5 m (16 ft) stratigraphically below P-31555 (Harrigan, 1995), includes parts of three high-spired, slender gastropods whose shells have been partially eroded away to reveal their inner morphology (Fig. 3I–J). The specimens are thin-shelled with slender, solid columella. The aperture, growth lines, and sutural characteristics are not visible due to recrystallization and erosion. One specimen (Fig. 3I) is 40 mm (1.6 inches) long and has an apical angle of 9°. The second specimen (Fig. 3J) is missing the apical angle but is even narrower than the first specimen and has an incomplete length of 44 mm (1.8 inches). The whorl sides are slightly concave to flat. A prominent palatal fold halfway along the whorl sides extends almost halfway into the whorl. A less prominent, thinner parietal fold occurs near the top of each whorl along the columella. The lower whorls are nearly twice as high as wide.

We identify these specimens as nerineid gastropods due to the presence of the palatal and parietal folds (cf. Cragin, 1905, pp. 96–98, pl. 20, figs. 1–3, pl. 21, figs. 4–5), which are absent in turritellid gastropods. In addition, turritellid gastropods have convex whorls that are usually wider than they are high rather than much higher than wide as in the Broken Jug specimens. A more precise identification is not possible, but it is significant that the gastropods from the Little Hatchet Mountains are not turritellids, as this gastropod family occurs in Cretaceous and younger rocks (Tracey et al., 1993). In contrast, the Nerineidae have a Jurassic–Cretaceous temporal range (Tracey et al., 1993), so they are not precise age indicators at the family level but do not preclude a Jurassic age.

Coral

We identify a coral from locality 4470, NMMNH P-31555 (Fig. 3K-L), as *Thamnasteria* sp. cf. *T. imlayi* Wells, 1942. The corallum of the single specimen is colonial, thamnasteroid, and ramose. The growth form is bushy to phaceloid in appearance. Branches are cylindrical and relatively narrow, 3–7 mm (0.1–0.3 inch) in diameter. Branch bifurcations are frequent, dichotomous, and irregularly spaced. Newly formed branches initially diverge from each other at an angle of ~30°–45° but, with further growth branches from the same stem, often exhibit a general trend toward subparallel orientation. The corallites are numerous, relatively small, closely spaced, and arranged perpendicular to the long axis of the branch. The calices are exclusively monocentric, and the calicular margins are generally circular in outline. Calice diameter ranges from 1.0 to 1.4 mm (0.04–0.06 inch), and the distance between the centers of calices ranges from about 1.4 to 1.8 mm (0.06–0.08 inch). The septa are well developed, solid, about 20–24 in number, and hexamerally arranged in three cycles, the third cycle possibly incomplete. The septa of the first and second cycles are subequal in size and extended nearly to the corallite axis. The septa of the third cycle are weakly developed, very much shorter than previous septa, and possibly incomplete. All septa are continuous beyond the calcicular margin as septocostae. The septocostae are then confluent between adjacent corallites. The columella is styliform, deep in the calice, and rarely observed due to recrystallization. Wall or other thecal structures were not observed.

NMMNH P-31555, as preserved, is about 75 mm (3 inches) in height and 160 x 45 mm (6.2 x 1.8 inches) in width. The subparallel alignment of branches on one side of the sample indicates that the actual height of the corallum was at least 120 mm (4.8 inches). Overall, the morphological details of the corallum are poorly preserved. Faint protuberances on the surfaces of some of the branches are relics of the corallites. The septal arrangement was observed only in a few of the exposed corallites on one small part of a branch. Details of the columella were not determined. Skeletal microstructure and internal skeletal architecture are not preserved.

The morphology of NMMNH P-31555 is, with minor exception, the same as that described for *Thamnasteria imlayi* Wells (1942, pp. 127–128, pl. 21, figs. 1–3). *Thamnasteria imlayi* Wells was originally described from samples retrieved from the Jurassic (probably Oxfordian) Smackover Limestone in the subsurface of Columbia

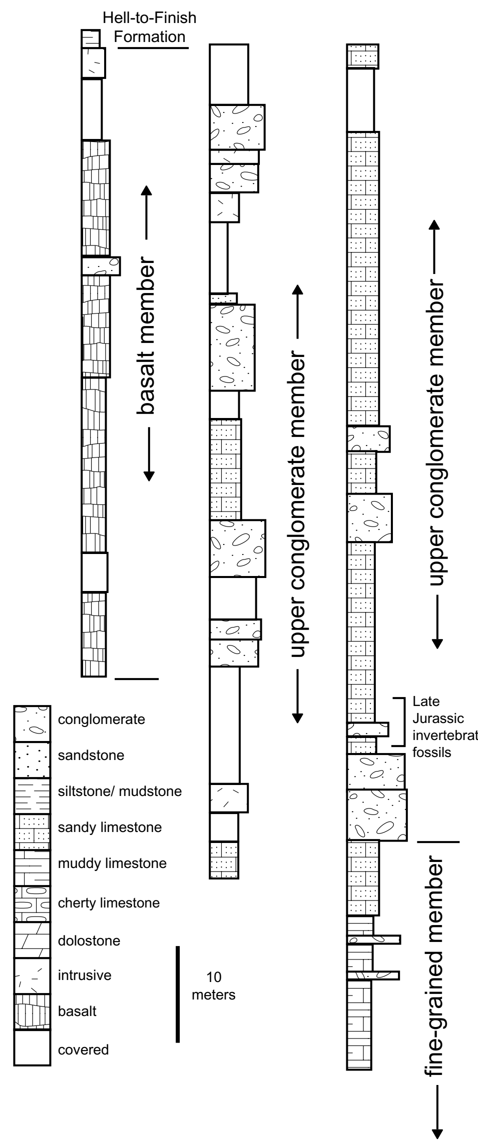
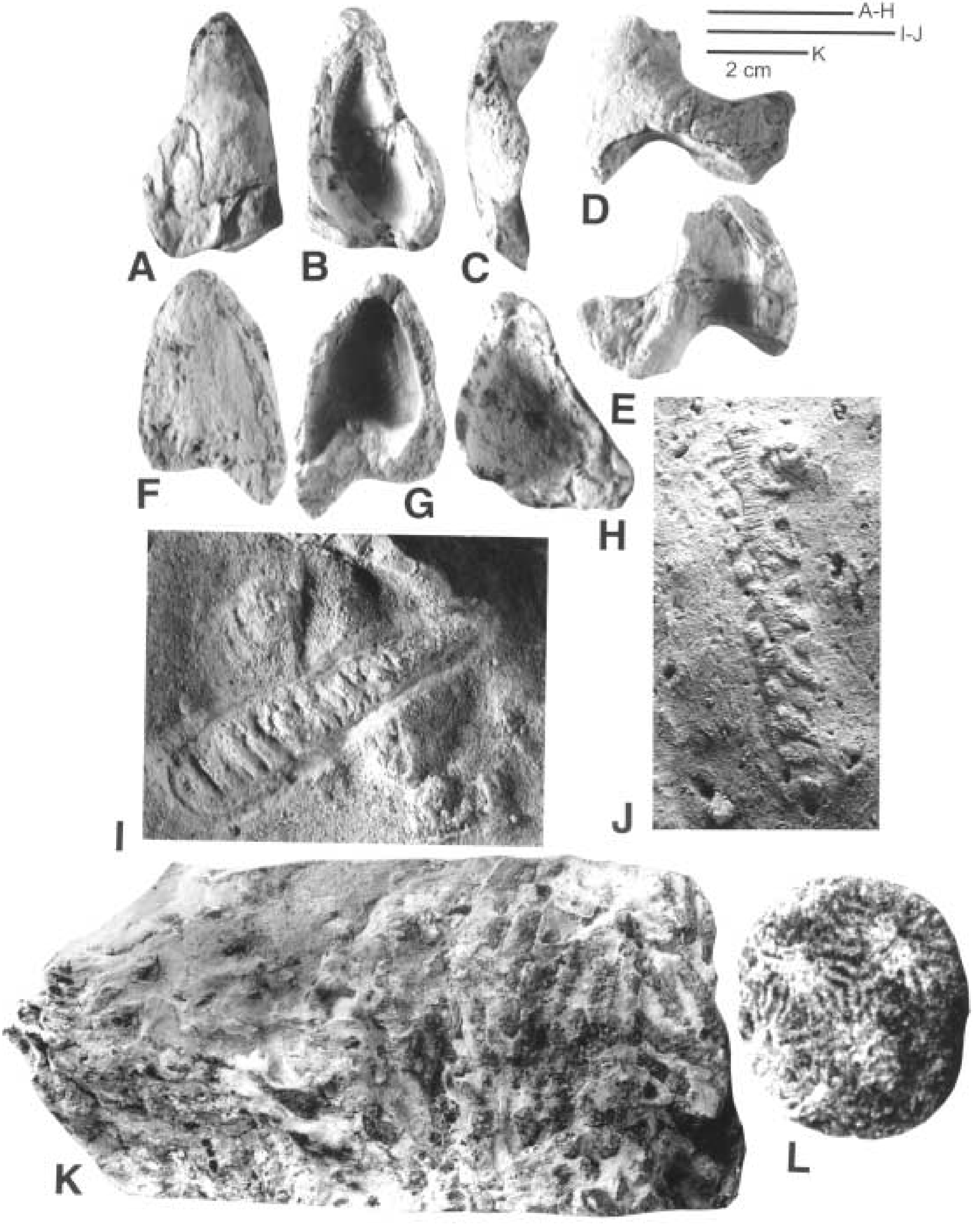


FIGURE 2—Stratigraphic section (right column lowest, left column highest) of part of the Broken Jug Formation showing stratigraphic position of invertebrate fossils described here. Modified from Lucas and Lawton (2000).


A-H
I-J
K
2 cm
A
B
C
D
E
F
G
H
I
J
K
L

County, Arkansas. The branches of the type material are slightly larger in diameter, from 10 to 20 mm (0.4–0.8 inch), but at the distal ends the diameter is only 5 mm (0.2 inch), which is within the range of measurements of the specimen from New Mexico. The diameters of the calices and spacing of the calicular centers of the New Mexico specimen essentially are the same as those of *T. imlayi*. The septal arrangement also appears to be the same. Comparisons with other Late Jurassic and Early Cretaceous members of this genus were given by Wells (1942).

The specimen of *Thamnasteria* sp. cf. *T. lamourouxii* Lesauvage, described by Reyeros de Castillo (1974, p. 16, pl. 3, figs. 1–3) from the Upper Jurassic of the Sierra del Águila, northern Chihuahua, appears to be similar both to the type material of *T. imlayi* and to the New Mexico specimen. The Chihuahua specimen has branches from 6 to 15 mm (0.2–0.6 inch) in diameter, calices 1.5 mm (0.06 inch) in diameter, and 18 septa. It is also interesting to note that the style of preservation of the Chihuahua specimen (see Reyeros de Castillo, 1974, pl. 3, figs. 1, 2) appears to be similar to that of the New Mexico specimen: both coralla are badly recrystallized and internally filled by gray or white sparry calcite. In addition, the sedimentary matrix of both specimens looks very similar.

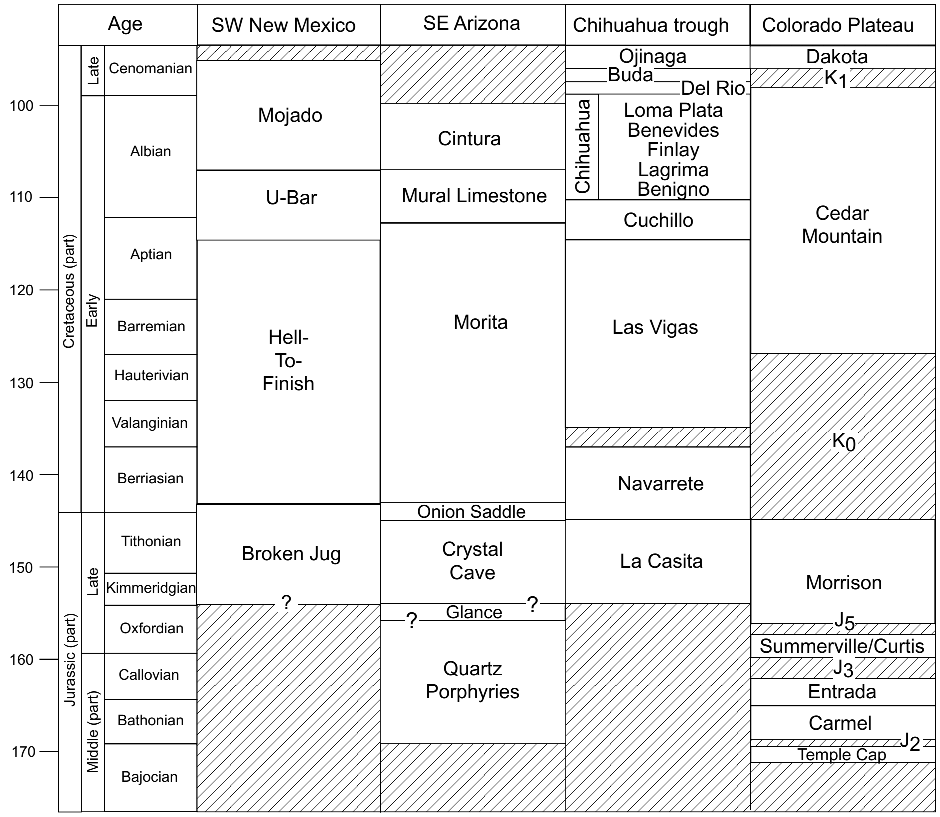


FIGURE 4—Preliminary correlation of Upper Jurassic and Lower Cretaceous stratigraphy of the Bisbee Basin in southwestern New Mexico and southeastern Arizona with strata of the Chihuahua trough (Monreal and Longoria, 1999) and the Colorado Plateau (Kowallis et al., in press).

Discussion

The fossils described here differ fundamentally from the Lower Cretaceous marine invertebrate fossils found in the Aptian–Albian U-Bar Formation, which until now yielded the oldest Mesozoic marine invertebrate fossils found in southwestern New Mexico. U-Bar invertebrate fossil assemblages are diverse, prolific, and dominated by bivalves such as *Exogyra*, *Ostrea*, *Ceratostreon*, and trigoniids, by rudistids, by turritellid gastropods, and, in some intervals, by ammonites and spatangoid echinoids (e.g., Lucas, 2000a, b; Lucas and Estep, 2000; Lucas and Lawton, 2000). In contrast, the Broken Jug Formation fossils from the Little Hatchet Mountains are of low diversity and abundance and are nerineid gastropods, which range in age from Jurassic to Cretaceous, and gryphaeid bivalves and a coral that clearly indicate a Late Jurassic age. They suggest broad correlation to the La Casita Formation of northern Mexico, which, based on its ammonoids, is Kimmeridgian to Tithonian in age (e.g., Monreal and Longoria, 1999).

This age range can be applied to the fossils described here and thus to part of the Broken Jug Formation. The entire Broken Jug Formation has been interpreted to represent a single lithosome deposited near the thick keel of the Bisbee rift basin (Lawton, 2000; Lucas and Lawton, 2000). So, a Late Jurassic age may be reasonable for the entire formation (Fig. 4).

The presence of Late Jurassic marine rocks in southwestern New Mexico (and in southeastern Arizona: Lawton and Olmstead, 1995; Olmstead and Young, 2000) has important implications for interpreting the Late Jurassic paleogeography of the Southwest. The nonmarine Morrison Formation was deposited across the southern Colorado Plateau during Late Jurassic time, and the southern edge of its basin of deposition was long considered to be an east-southeast-trending uplift, the "Mogollon highlands," in west-central New Mexico and east-central Arizona (Smith, 1951; Harshbarger et al., 1957; Lucas and Anderson, 1997). However, some workers (notably Bilodeau, 1986) have questioned the location of these highlands, placing them farther south, in northern Mexico and southwestern Arizona. Nevertheless, simultaneous Late Jurassic marine deposition in the Bisbee Basin of southwestern New Mexico-southeastern Arizona and fluvial deposition (with some northerly paleoflow indicators) of the Morrison Formation on the southern Colorado Plateau necessitates a highland between the two depositional systems (Fig. 5).

We regard the Burro uplift (Elston, 1958), lying directly north of the Bisbee Basin, as the drainage divide between north-draining Morrison fluvial systems and contemporary marine deposits to the south. This topographically elevated rift shoulder lay north of the Bisbee Basin in the Early Cretaceous and provided a source for detritus of the Hell-to-Finish Formation (Bilodeau and Lindberg, 1983; Mack et al., 1986), which overlies the Broken Jug Formation (Fig. 4). We infer that the rift shoulder, with a steep southern escarpment facing the Bisbee Basin and a gentle northern flank forming the headwaters of Morrison rivers, was established at least as early as Late Jurassic time.

Acknowledgments. Phil Harrigan found some of the fossils described here. Orin Anderson, Jerry Harris, and Pete Reser assisted in the field. William R. Dickinson, Barry S. Kues, and Gary Olmstead provided helpful reviews of the manuscript.

FIGURE 3—Late Jurassic invertebrate fossils from the upper conglomerate member of the Broken Jug Formation, Little Hatchet Mountains. **A–H**, cf. *Gryphaea mexicana*; **A–B**, NMMNH P-32959, left valve, external (**A**) and internal (**B**) views; **C**, **H**, NMMNH P-32958, left valve, side (**C**) and internal (**H**) views; **D-E**, NMMNH P-32957, fragmentary left valve, external (**D**) and internal (**E**) views; **F–G**, NMMNH P-32960, left valve, external (**F**) and internal (**G**) views. **I–J**, Nerineidae, NMMNH P-31554. **K–L**, *Thamnasteria* sp. cf. *T. imlayi*, NMMNH P-31555, lateral view of corallum (**K**) and detail of calices (**L**). Note that **L** is 12 times larger than **K**.

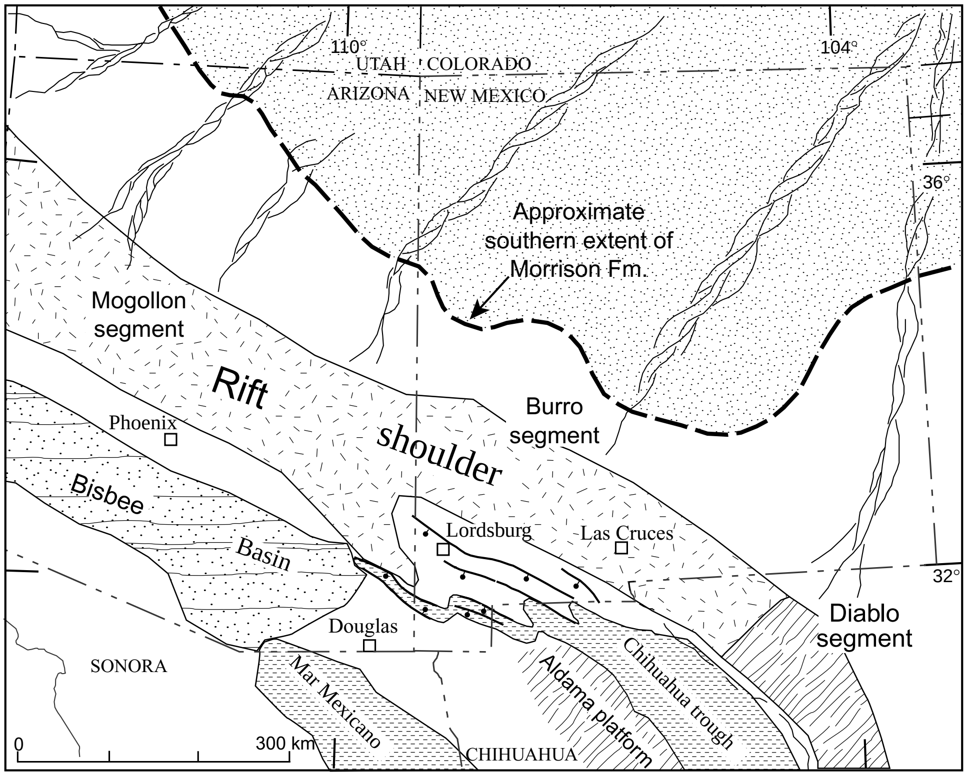


FIGURE 5—Simplified paleogeographic map of Arizona–New Mexico during the Late Jurassic (Kimmeridgian) deposition of the Broken Jug Formation and the Salt Wash Member of the Morrison Formation. Braided fluvial systems drained northeastward from a rift shoulder that lay northeast of the marine embayments of the Chihuahua trough and the Mar Mexicano, which was initiated slightly earlier, in late Oxfordian time, upon cessation of a Triassic–late Middle Jurassic magmatic arc. These two marine basins were separated by the Aldama platform, underlain by upper Paleozoic sedimentary rocks. The rift shoulder is here divided into three segments, the Mogollon, Burro, and Diablo segments. Basal strata of the part of the Bisbee Basin indicated by the sandstone pattern are poorly dated, and their Jurassic distribution is inferred from the extent of Lower Cretaceous rocks of the Bisbee Basin (Bilodeau and Lindberg, 1983). Southern extent of Morrison exposures is an erosional limit beneath the Cenomanian Dakota Sandstone. After Blakey (1989), Peterson (1994), Lucas and Anderson (1997), Robinson and McCabe (1997), Cather (1999), and Lawton (2000).

References

Bilodeau, W. L., 1986, The Mesozoic Mogollon highlands, Arizona—an Early Cretaceous rift shoulder: Journal of Geology, v. 94, pp. 724–735.

Bilodeau, W. L., and Lindberg, F. A., 1983, Early Cretaceous tectonics and sedimentation in southern Arizona, southwestern New Mexico, and northern Sonora, Mexico; *in* Reynolds, M. W., and Dolly, E. D. (eds.), Mesozoic paleogeography of west-central United States: Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, Denver, CO, pp. 173–188.

Blakey, R. C., 1989, Triassic and Jurassic geology of the southern Colorado Plateau; *in* Jenney, J. P., and Reynolds, S. J. (eds.), Geologic evolution of Arizona: Arizona Geological Society Digest, Tucson, v. 17, pp. 369–396.

Cather, S. M., 1999, Implications of Jurassic, Cretaceous, and Proterozoic piercing lines for Laramide oblique-slip faulting in New Mexico and rotation of the Colorado Plateau: Geological Society of America, Bulletin, v. 111, pp. 849–868.

Cragin, F. W., 1905, Paleontology of the Malone Jurassic Formation of Texas: US Geological Survey, Bulletin, v. 266, 172 pp.

Elston, W. E., 1958, Burro uplift, northeastern limit of sedimentary basin of southwestern New Mexico and southeastern Arizona: American Association of Petroleum Geologists, Bulletin, v. 42, pp. 2513–2517.

Felix, J., 1891, Versteinerungen aus der mexicanischen Jura–und Kreide-Formation: Palaeontographica, v. 37, pp. 140–199.

Harrigan, P. J., 1995, Stratigraphy, depositional environments, and tectonic setting of the Broken Jug Formation (Late Jurassic?–Early Cretaceous) in the Little Hatchet Mountains, southwestern New Mexico: Unpublished MS thesis, New Mexico State University, Las Cruces, 101 pp.

Harshbarger, J. W., Repenning, C. A., and Irwin, J. H., 1957, Stratigraphy of the uppermost Triassic and the Jurassic rocks of the Navajo country: US Geological Survey, Professional Paper 291, 74 pp.

Imlay, R. W., 1940, Upper Jurassic pelecypods from Mexico: Journal of Paleontology, v. 14, pp. 393–411.

Kowallis, B. J., Christiansen, E. H., Deino, A. L., Zhang, C., and Everett, B. H., in press, The record of Middle Jurassic volcanism in the Carmel and Temple Cap formations of southwestern Utah: Geological Society of America, Bulletin.

Lawton, T. F., 2000, Inversion of Late Jurassic–Early Cretaceous extensional faults of the Bisbee Basin, southeastern Arizona and southwestern New Mexico; *in* Lawton, T. F., McMillan, N. J., and McLemore, V. T. (eds.), Southwest passage—a trip through the Phanerozoic: New Mexico Geological Society, Guidebook 51, pp. 95–102.

Lawton, T. F., and Harrigan, P. J., 1997, Jurassic strata of the Little Hatchet Mountains, Hidalgo County, New Mexico (abs.): New Mexico Geology, v. 19, p. 57.

Lawton, T. F., and Olmstead, G. E., 1995, Stratigraphy and structure of the lower part of the Bisbee Group, northeastern Chiricahua Mountains, Arizona, USA: Geological Society of America, Special Paper 301, pp. 21–39.

Lucas, S. G., 2000a, A new species of the echinoid *Hemiaster* from the Lower Cretaceous (Albian) of southwestern New Mexico: New Mexico Museum of Natural History and Science, Bulletin 16, pp. 101–106.

Lucas, S. G., 2000b, Lower Cretaceous ammonites from southwestern New Mexico; *in* Lawton, T. F., McMillan, N. J., and McLemore, V. T. (eds.), Southwest passage—a trip through the Phanerozoic: New Mexico Geological Society, Guidebook 51, pp. 195–201.

Lucas, S. G., and Anderson, O. J., 1997, The Jurassic San Rafael Group, Four Corners region; *in* Anderson, O. J., Kues, B. S., and Lucas, S. G. (eds.), Mesozoic geology and paleontology of the Four Corners region: New Mexico Geological Society, Guidebook 48, pp. 115–132.

Lucas, S. G., and Estep, J. W., 2000, Stratigraphy, paleontology, and correlation of the Lower Cretaceous Carbonate Hill Member of the U-Bar Formation, East Potrillo Mountains, New Mexico: New Mexico Museum of Natural History and Science, Bulletin 16, pp. 81–86.

Lucas, S. G., and Lawton, T. F., 2000, Stratigraphy of the Bisbee Group (Jurassic–Cretaceous), Little Hatchet Mountains, New Mexico; *in* Lawton, T. F., McMillan, N. J., and McLemore, V. T. (eds.), Southwest passage—a trip through the Phanerozoic: New Mexico Geological Society, Guidebook 51, pp. 175–194.

Mack, G. H., Kolins, W. B., and Galemore, J. A., 1986, Lower Cretaceous stratigraphy, depositional environments, and sediment dispersal in southwestern New Mexico: American Journal of Science, v. 286, pp. 309–331.

Monreal, R., and Longoria, J. F., 1999, A revision of the Upper Jurassic and Lower Cretaceous stratigraphic nomenclature for the Chihuahua trough, north-central Mexico—implications for lithocorrelations: Geological Society of America, Special Paper 340, pp. 69–92.

Olmstead, G. A., and Young, K., 2000, Late Jurassic ammonites from the northeastern Chiricahua Mountains, southeast Arizona: New Mexico Geology, v. 22, pp. 1–7.

Peterson, F., 1994, Sand dunes, sabkhas, streams, and shallow seas—Jurassic paleogeography in the southern part of the Western Interior basin; *in* Caputo, M. V., Peterson, J. A., and Franczyk, K. J. (eds.), Mesozoic systems of the Rocky Mountain region, USA: Society for Sedimentary Geology, Rocky Mountain Section, Denver, CO, pp. 233–272.

Reyeros de Castillo, M. M., 1974, Corales del Jurásico Superior de Chihuahua: Universidad Nacional Autónoma de México, Instituto de Geología, Paleontología Mexicana, Número 40, pp. 5–41.

Robinson, J. W., and McCabe, P. J., 1997, Sandstone-body and shale-body dimensions in a braided fluvial system—Salt Wash Sandstone Member (Morrison Formation), Garfield County, Utah: American Association of Petroleum Geologists, Bulletin, v. 81, p. 1267–1291.

Smith, C. T., 1951, Problems of Jurassic stratigraphy of the Colorado Plateau and adjoining region; *in* Smith, C. T., and Silver, C. (eds.), San Juan Basin (New Mexico and Arizona): New Mexico Geological Society, Guidebook 2, pp. 99–102.

Tracey, S., Todd, J. A., and Erwin, D. H., 1993, Mollusca: Gastropoda; *in* Benton, M. J. (ed.), The fossil record 2: Chapman and Hall, London, pp. 131–167.

Wells, J. W., 1942, Jurassic corals from the Smackover Limestone, Arkansas: Journal of Paleontology, v. 16, pp. 126–129.

Zeller, R. A., 1970, Geology of Little Hatchet Mountains, Hidalgo and Grant Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 96, 26 pp.